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ABSTRACT

This series of experiments seeks to provide laboratory exercises which demonstrate concepts in Earth Science, particularly oceanology. Materials used in the experiments are easily obtainable. Examples of experiments include: (1) comparison of water hardness; (2) preparation of fresh water from sea water; (3) determination of water pressure; (4) measuring water clarity; (5) collection and analysis of water samples; (6) study of waves; (7) beach formation and erosion; (8) density currents; and (9) study of icebergs. (RE)

HOW TO... Activities in Physical Oceanography

National Science Teachers Association

by
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Introduction

One problem often encountered in the teaching of Earth Science is the shortage of laboratory activities that can be used to illustrate important concepts in a clear, meaningful and relevant manner. It is the intent of this pamphlet to provide such activities for Physical Oceanography.

Activities have been gathered from many diverse sources, modified, and adapted to a consistent outline form. The materials and equipment used have intentionally been held to a minimum and are easily obtainable. The use of difficult terminology, likewise, has been held to a minimum.

Although these activities have been written for, and have for the most part, been tested by junior high school students, they are appropriate for use by older students as well.

We hope these activities will aid teachers or others who may wish to try them. Comments pursuant to the subsequent revision and improvement of this pamphlet will be appreciated by the authors.

Donald N. Nimmer
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Water Hardness

Introduction

The term "hardness" refers to the total amount of dissolved minerals found in a water sample. The "harder" a water sample, the more dissolved minerals it contains; the "softer" the water sample, the fewer dissolved minerals it contains. This activity is divided into two parts—each using a different method of showing the relative hardness of water samples.

Part A: Comparison of Water Hardness: Evaporation Method[1]

Introduction

Water evaporates, or turns into a gas (water vapor), when it is heated. The minerals dissolved in the water are unable to evaporate, so they remain behind. When all the water has evaporated, you can measure the total amount of minerals the water contained.

Materials

Water Samples
Distilled water, Lake water, River water, Well water, Ocean water, City water.
6 Evaporating Dishes
Balance
Heat Source
Ring Stand
6 Filter Papers
Funnel
Graduated Cylinder

Procedure

1. Filter each water sample to remove any suspended (nondissolved) materials. Use a clean filter paper for each sample.
2. Label and weigh each evaporating dish. Record their weights onto a data chart.
3. Pour 25 ml. of each water sample into the proper evaporating dishes.
4. Heat the evaporating dishes until all of the water is evaporated from each.
   CAUTION: As most of the water evaporates, splattering of the "soupy" remains can occur, therefore, heat the sample more slowly.
5. After the evaporating dishes cool, weigh each one again and record the weights onto a data chart.
6. Find the weight of the minerals left behind in each sample. (Weight of minerals = weight of evaporating dish and minerals minus the weight of the evaporating dish.)

Data

For each water sample, record the weights of the evaporating dish, the evaporating dish plus minerals, and the mineral.

Questions

1. Place the water samples in the order of their hardness.
2. Remembering what was happening to the water's hardness while the water evaporated, think about the following: The Great Salt Lake was once a large fresh water lake—now, it is very salty and much smaller. Design an experiment to show how this could have happened.

Part B: Comparison of Water Hardness: Soap Method[2]

Introduction

The hardness of water can be found by adding soap to it. The more soap that is needed to make a lasting lather (soap bubbles) the "harder" the water is. The less soap that is needed, the fewer dissolved minerals are present.

Materials

Water Samples:
Distilled water, Lake water, River water, Well water, Ocean water, City water.
Liquid Dishwashing Soap
Eye Dropper
6 Containers with lids
Funnel
6 Filter Papers
Graduated Cylinder

Procedure

1. Filter each water sample to remove any suspended (nondissolved) materials. Use a clean filter paper for each sample.
2. Pour 50 ml. of each sample into a properly labeled container (with lid).
3. Since Distilled Water contains no dissolved minerals, it will be used as a STANDARD with which the other water samples will be compared.
   a. Add one drop of soap to the distilled water.
   b. Shake the sample.
   c. Repeat steps "a" and "b" until a lasting lather (soap bubbles) remain on the water surface.
   d. Record the total number of drops onto a data chart.
4. Following the procedure outlined for Distilled Water in steps "3a-3d," find the number of soap drops needed to produce a lasting lather in each of the other water samples.
   Record the results onto a data chart.

Data

For each water sample, record the number of soap drops required to produce a lasting lather on the water's surface.

Questions

1. Place the water samples in order of their hardness.
2. If you were to take a bath in these different types of water, which would require you to use the most soap?
   In which would you use the least soap?
3. What is the "Soft Water" used in some homes?
   How is it made?
   Why do the advertisers of soft water machines claim you will save money on soap when you use soft water?

Fresh Water From Sea Water

Introduction

Water is probably the most important substance on earth for the continuation of life. Although about two-thirds of the earth's surface is covered with ocean water, there are so many dissolved minerals present that we cannot consume the water in that form. This activity outlines two different ways that the dissolved minerals may be removed from ocean water. Part A uses a boiling process while Part B used a freezing process.

Part A: Fresh Water From Ocean Water: Distillation Method

Introduction

When ocean water is boiled, steam is produced and the dissolved solids remain behind. Since steam contains very few, if any, dissolved minerals, pure liquid water results when the steam is captured, cooled, and condensed. This process is called distillation.

Materials

Ocean water
Graduated cylinder
Flask
Beaker
One-hole rubber stopper
Ring stand
Clamp
Heat Source

Procedure

1. Taste the ocean water. Record its taste in the Data Section.
2. Pour exactly 50 ml. of ocean water into the flask.
3. Clamp the flask to the ring stand.
   Insert the stopper and glass rod into the top of the flask.
   Place a clean beaker under the end of the glass tube as in Figure 1.
4. Slowly boil the ocean water until all of the water has evaporated.

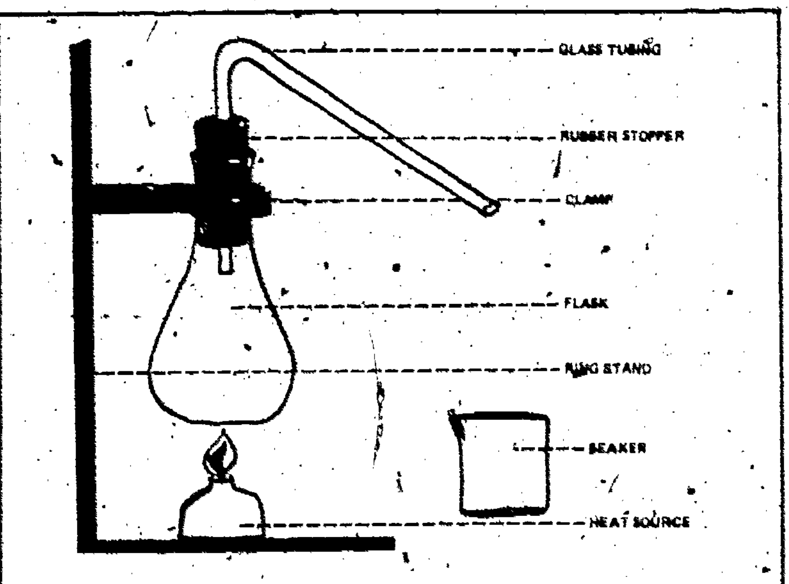

FIGURE 1. DISTILLATION APPARATUS

5. Taste the water that was captured in the beaker. Record its taste in the Data Section.
6. Measure how much water was captured in the beaker. Record this in the Data Section.

Data

1. Taste of the Ocean Water
2. Taste of the "Distilled" Water
3. Amount of the "Distilled" Water

Questions

1. a. Why does the distilled water taste differently than the ocean water?
   b. What happened to the dissolved minerals?
2. If the amount of distilled water collected was less than 50 ml., explain how the water may have been lost.
3. a. Could this distillation process be used on a larger scale to obtain fresh water from ocean water?
   b. Would it be practical?
   Explain.

Part B:
Fresh Water From Ocean Water: Freezing Method

Introduction

When ocean water is frozen, its upper layers of ice are mainly made of pure water with some dissolved minerals present. If this ice could be melted and refrozen, more dissolved minerals could be removed. Repetition of this process would result in purer water.

Materials

Ocean water
Freezer
Containers (approximately one pint in size and freezer safe)
Labels
Bowl

Procedure

1. Pour ocean water into a container labeled #1.
   This will be used as a comparison sample.
2. Fill a container three-fourths full of ocean water and set it in the freezer.
3. When one-half of the water is frozen, remove the container from the freezer.
   Wash the ice with cold water to remove the ocean water film.
4. Melt the ice in a bowl.
   Save a small sample of this water in a container labeled #2.
   Place the rest of the water in the freezer.
5. Repeat steps #3 and #4 several times.
   Remember to label the water samples saved in a consecutive order.

Data

Taste each water sample and place them in order of their saltiness.

Questions

1. Why did the water samples change taste after being frozen?
2. Could this process be used on a larger scale to get fresh water from ocean water?
   Explain its practicality.

Water Pressure and Depth

Introduction

In this activity, the relationship between water pressure and water depth will be investigated. To get the maximum understanding from this exercise, it would be helpful to do both parts in the order in which they are presented.

Part A:
Squeeze-bottle, Pressure, and Water Stream Shape[3]

Introduction

When water is forced from a squeeze-bottle by differing amounts of pressure, water streams of differing shape result. (This activity is best done outside.)

Materials

Squeeze-bottle (A liquid dish soap container works well.)
Water

Procedure

1. Fill the squeeze-bottle with water.
2. Hold the bottle horizontally.
3. Lightly squeeze the bottle with your hand.
   Draw the squeeze-bottle in the Data Section.
   Draw and label a line showing the steam's path.
4. Refill the bottle with water.
   Hold the bottle horizontally and squeeze it harder than you did before.
   Draw and label this water stream on the

diagram.

5. Refill the bottle again.
   This time, squeeze the bottle as hard as possible.
   Draw and label this stream of water.

Questions

1. What happened to the water's path as you squeezed the bottle harder?
2. Therefore, the greater the pressure, the ______________________ water's path will be.

Part B:
Pressure Change With Depth

Introduction

The change of water pressure with depth will be investigated in this activity.

Materials

Tall Metal or Plastic Container (about 12" or more)
Hammer
Nail
Water

Procedure

1. Make three holes of the same size, one above the other, in the container.
   One should be near the bottom, one about 1/3 the way up, and, the last, 2/3 the way up from the bottom.
   (If the container is plastic, use a hot nail to melt the hole through.)
2. Keeping the container continually filled with water, watch the streams of water coming from the holes.
3. In the Data Section, draw a side-view of the container, its holes, and the water streams coming from it.

Questions

1. Which stream (top, middle, or bottom) indicates the greatest water pressure?
   How can you tell?
   Explain why this part of the container would have the greatest water pressure.
2. What happens to the water pressure as you go deeper in a swimming pool, lake, or ocean?
3. If you were going to build a concrete dam across a river so that a large lake would form behind it, where should the dam be the thickest?
   Explain why:

Measuring the Clarity of Water

Introduction

The clarity or clearness of water is measured with a Secchi Disk. This activity is divided into two parts. Part A will be concerned with making a Secchi Disk and Part B will be concerned with using the Secchi Disk.

Part A:
Making a Secchi Disk[4]

Introduction

The Secchi Disk is used in measuring the clarity of water. Since it will be lowered into water, it must be heavy and resistant to water damage. Metals make the best Secchi Disks, but, painted wood with lead weights may be substituted.

Materials

Metal Plate, 20 cm. in diameter (about 7.8").
¼ inch Eyebolt
Swivel Snap
Twenty (20) feet of ⅛" Nylon Rope.
Black Paint (enamel)
White Paint (enamel)
Paint Brush
Masking Tape
Drill with a ¼" Bit

Procedure

1. Drill a ¼" hole in the center of the metal plate.
2. Paint the entire plate black.
3. After the black paint dries, divide the top into four equal wedges with strips of masking tape.
4. Paint two opposite wedges white and leave the remaining two wedges black.
5. Remove the masking tape when the paint dries.
6. Fasten the ¼" eyebolt in the center of the plate so the "eye" will be on the black and white surface.
7. Attach the ⅛" nylon rope to the swivel snap's eye.
8. Snap the swivel snap to the eyebolt.
9. Mark the rope in feet and inches above the Secchi Disk.

Questions

1. Why do you think Secchi Disks are used in finding the clarity of water?
2. Why do you think all Secchi Disks are the same size and color?

Part B:
Using the Secchi Disk[5]

Introduction

The Secchi Disk is lowered into the water until it can no longer be seen—this point is called the "Limit of Visibility." The clearer the water, the deeper this point is. By comparing the Limit of Visibility from one water body to another, you are actually comparing their clarity.

Materials

Secchi Disk
Boat
Face Mask

Sunny, Calm Day

Procedure

1. Lower the Secchi Disk into the water on the shaded side of the boat.
2. Looking through the face mask on the water's surface, record the depth at which the Secchi Disk disappears.
3. Slowly lift the disk until it can be seen again. Record this depth.
   The average of these two depths (steps 2 + 3) is considered to be the real Limit of Visibility.
4. Use the Secchi Disk in several different bodies of water.

Questions

1. Do all bodies of water have the same Limits of Visibility? From the bodies of water you have sampled, which is the clearer: Lake water or River water?
2. Explain why some water bodies are clearer than others.

Collecting and Analysing Water Samples From Different Depths.

Introduction

When studying large bodies of water, scientists are not only concerned with what things are like at the water's surface, but what conditions are like beneath the surface as well. This activity is divided into three parts: Part A deals with making a water collecting bottle useable at different depths, Part B is concerned with actually using the sample collecting bottle, and Part C shows how to analyze the water samples that have been collected.

Part A
Making a Deep Water Sampler[6]

Introduction

An instrument used to collect water samples depth must be heavy enough to sink easily, it must remain closed until it reaches the desired depth, and it must be readily opened to let in the water.

Materials

Heavy Bottle with a small opening (a Quart Soda Pop Bottle works well)
One-hole Rubber Stopper (to fit bottle opening)
20 - 30 lead Fishing Sinkers
Two 20 foot lengths of 1/8" Nylon Rope
Two 10 inch lengths of Nylon Cord

Procedure

1. Tie the lead sinkers at one inch intervals to the nylon cord. (Additional and/or heavier sinkers may be required for deeper water.)
2. Tie these cords tightly around the lower part of the sample bottle.
3. Tie one 20 foot length of nylon rope around the neck of the bottle.
4. Push one end of the other nylon rope through the rubber stopper's hole.
   Tie the rope's end into a knot that will not slip through the hole.
5. Mark the rope (in Step #4) in feet and inches from the rubber stopper.

Part B:
Using the Water Sampler[7]

Materials

Water Sampler (Made in Part A)
Boat
Thermometer
Bottles with lids
Labels
Map of the Water Body
Styrofoam Picnic Cooler for storage of water samples

Procedure

1. Position the boat in the desired sampling area. This position should be marked on the map and recorded on all water sample labels.
2. The first water sample will be taken at the water's surface.
   a. Remove the water sampler's rubber stopper and fill the bottle with water.
   b. Bring the sampler into the boat.
   c. Measure the water's temperature with a thermometer held two-thirds the way down for three minutes. Record this temperature on the Data Sheet in Part C.
   d. Pour the water sample into another bottle, cap it, label it as the surface sample, and keep it cool until it can be analyzed in the lab. (These are best stored in a picnic cooler.)
3. Snuggly—but not tightly—insert the rubber stopper into the sampler's opening.
   a. Lower the sampler by its ropes to the next depth desired (i.e., 4 feet).
   b. Tug only the rope attached to the rubber stopper until the stopper is freed.
   c. When the sampler is filled with water (this will take about 1 minute) pull it to the surface.
   d. Take its temperature and record it on the Data Sheet in Part C.
   e. Pour this water sample into a properly labeled bottle and store until it can be analyzed.
4. Repeat step #3 at similar depth intervals.

Part C:
Analyzing the Water Samples[8]

Materials

Filter Paper
Glass Funnel

Graduated Cylinder
Microscope
Slides
Coverslips
Eye Dropper
Evaporating Dish
Heat Source
Ring Stand
Balance
Beakers
A key to Aquatic Organisms (from the Library or Biology room).

Procedure

1. Shake the water sample obtained from the surface. Measure exactly 100 ml. of the sample with the graduated cylinder.
2. Weigh a piece of filter paper on the balance. Fold the filter paper and place it in the funnel. Place a pre-weighed 150 ml. beaker under the funnel. Pour the 100 ml. of water sample through the filter. (All suspended material, both living and non-living, will be trapped in the filter paper.) Let the filter paper remain in the funnel until it is thoroughly dry.
3. Weigh the dry filter paper with its trapped material. The total weight of the suspended material in 100 ml. of sample will be:

   Weight of suspended material = Weight of Filter Paper plus Trapped Material − Weight of dry Filter Paper

   Record this weight on the Data Sheet.
4. Evaporate the water from the beaker by using the heat source. (The dissolved solids will be left behind in the beaker.)

   Weight of Dissolved Solids = Weight of Beaker plus Solids − Weight of Beaker

   Record this weight on the Data Sheet.
5. Place one drop of the water sample (from the labeled bottle) on a glass slide. Cover with a coverslip. Observe what organisms are present by using the microscope. Try identifying the organisms by using a Key to Aquatic Organisms from the library or from your teacher. Record the organisms present on the Data Sheet.
6. Repeat steps 1-5 for each water sample obtained.

Data

Location and depth of water sample	Temperature	Weight of Suspended Material per 100 ml	Weight of Dissolved Solids per 100 ml	Organisms Present

Questions

1. How did the temperature change as you went deeper?
2. How did the amount of suspended material change with depth?
3. How did the amount of dissolved minerals change with depth?
4. How did the types of organisms change with depth?
5. Would it be helpful to graph each of these factors against depth? How would you do it? Try it and show your results.

Waves

Introduction

The waves found on a body of water are usually caused by the wind. The first part of this activity will explore how this happens and what the resultant waves are like. The second part of this activity deals with a more unusual type of wave—tidal waves—caused by earthquakes.

Part A
Waves Caused by Wind[9]

Materials

Sand (damp)
Water
Long shallow pan
3-speed fan

Procedure and Questions

1. Make a sand beach on one end of the pan.
2. Slowly add water to the pan. Allow the water to settle completely before continuing.
3. Set the fan at the water end of the pan.
4. Turn the fan on "Low."
   What happens to the water's surface?
   What happens to the wave size as the fan continues to blow at the "low" speed for several minutes?
5. Turn the fan on "Medium."
   How does the wave size produced now com-

pare with that produced when the fan was on "Low"?

6. Turn the fan on "High."
How do the waves now produced compare with those formed when the fan was on "Low" or "Medium"?

7. From this activity, what two factors about the wind seem to effect wave size?

Optional Procedure: Wave Shape

1. With the fan continuing to blow across the water, study the shape of the waves as they approach the sand beach.

Part B
Tidal Waves[10]

Introduction

Tidal waves are caused by earthquakes or sudden shifting of the earth's crust. This activity will be done without the fan, so let the water settle completely before beginning.

Materials

Sand (damp)
Water
Long shallow pan

Procedure

1. Set up the pan, water, and sand exactly as it was in Part A of this activity.
2. Lift one end of the pan about three (3) inches.
3. Drop the end of the pan.

Questions

1. Describe the wave produced when the end of the pan was dropped.
2. What differences did you notice about the size and number of waves produced by tidal waves as compared to those produced by wind action?
3. Why do you think so much damage and flooding can result from tidal waves?
4. Read about tidal waves in an earth science textbook. What is another name for tidal waves?
How are the tidal waves related to the tides?

Beach Formation and Erosion[11]

Introduction

The continual pounding of waves on a shore will erode and shape it over and over again in a never ending series of beach patterns. This activity explores this process in the laboratory, however, if a natural shore is accessible, it would be helpful for the student to observe the actual processes in action.

Materials

Long shallow pan
Sand (damp)
Water
3-speed fan
Block of wood

Procedure

1. Fill one end of the pan with damp sand. Have the beach end in a straight steep manner. Place the fan at pan end opposite the beach.
2. Raise the sand end about one inch above the horizontal by setting it on the wood block.
3. Fill the remainder of the pan with water. (Pour the water slowly so it will not disturb the sand.)
4. Turn the fan on "Low."
5. Watch the shoreline change shape.
6. Make a cross-sectional drawing of the beach every five minutes for a half hour.

Questions

1. How did the beach change shape over a period of time?
2. What do you think would happen if you allowed the activity to continue for several days?
3. Briefly explain how the waves are able to erode and change the beach shape.
4. Explain how you could change this activity to show the effects of the angle at which the waves strike the shore.
Explain how you could change this activity to show the effects of the speed and size of the waves striking the shore.
Try your suggested changes and report on the results.

Density Currents

Introduction

Many lake and ocean currents are caused by differences in water density from one part of the water body to another. These differences in density are caused by differences in temperature and/or amounts of dissolved solids present in the water. This activity shows water movements caused by both temperature and the amount of dissolved solids.

Materials

3 Glass bottles of equal size
Food coloring
Heat source
Fresh water
"Sea" Water
Cardboard square (large enough to cover the bottle tops)

Procedure

1. a. Fill two bottles with fresh water.
   b. Add food coloring to one of these bottles.
   c. Heat the other bottle of fresh water.
   d. Cover the warmed bottle with the cardboard square.
   e. Carefully turn this bottle upside down and fit it to the top of the cool bottle of colored fresh water. Remove the card-

board.

f. Answer question #1 of the Data Section.

g. Repeat the entire process. However, this time placing the cool bottle on top.

h. Answer questions #2 and #3 of the Data Section.

2. a. Fill one bottle with "sea" water and one with fresh water.

b. Add food coloring to the "sea" water.

c. Cover the "sea" water bottle with the cardboard.

d. Turn it upside down and fit it to the top of the fresh water bottle. Remove the cardboard.

e. Answer question #4 of the Data Section.

f. Repeat the process, however, this time place the fresh water bottle on top.

g. Answer questions #5 and #6 of the Data Section.

Data

1. How much did the warm water and cool water mix when the warm water was on top?
   How could you tell?
2. How much did the warm water and cool water mix when the cool water was on top?
   How could you tell?
3. Using your observations from questions #1 and #2, which temperature of water is heavier—warm or cool?
   What evidence do you have to support this conclusion?
4. How much did the fresh water and "sea" water mix when the "sea" water was on top?
   How could you tell?
5. How much did the fresh water and "sea" water mix when the fresh water was on top?
   How could you tell?
6. Using your observations from questions #4 and #5, which type of water is heavier—water of "sea" water?
   What evidence do you have to support this conclusion?
   Which type of water has more dissolved solids—fresh water or "sea" water?
   What will this mean about its density?

Questions

Using the information gained from this activity explain the following:

1. When the Mississippi River enters the Gulf of Mexico, the river water actually flows on top of the ocean water for a noticeable distance. Expalin why.
2. A large density current exists between the Equator and the Poles. In the Northern Hemisphere the surface waters flow from the Equator toward the North Pole, while the deeper water flows from the North Pole toward the Equator. Explain what is happening in this current.

Icebergs

Introduction

When glaciers terminate in a body of water, chunks of ice break off and float about freely. Also, when surface ice, resulting from the freezing of the water body's upper layers, breaks up the resulting pieces likewise float about in the water. The appearance of the floating ice masses is very deceiving as will be shown in this activity.

Materials

Beaker
Water
Ice cubes
Ruler

Procedure

1. Fill the beaker ¾'s full of cool water.
2. Drop the ice cube into the water.
3. Measure the total thickness of the ice cube and record this in the Data Section. Measure the amount of the ice cube above the water. Measure the amount of the ice cube below the water's surface.
4. Calculate the actual percentage of the ice cube's size that is above the water's surface.

Data

Total ice cube thickness: ____________
Thickness above the water's surface: ______
Thickness below the water's surface: ______
Percent of the ice cube's size that is above the water's surface: ____________

Questions

1. Is more of the ice cube above or below the water's surface?
2. If you saw an iceberg in the water while you were riding in your speedboat, why would it be dangerous to speed very close to it?
3. What was the Titanic?
   Explain what happened to it.

Footnotes

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